

JC10 Rec'd PCT/PTO 15 FEB 2002

FORM PTO 1390 (REV. 11-2000)	U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY DOCKET NUMBER
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		825-161
		U.S. APPLICATION NO. (if known, see 37 CFR 1.5) 10/049690

INTERNATIONAL APPLICATION NO. PCT/EP00/08084	INTERNATIONAL FILING DATE 08/18/2000	PRIORITY DATE CLAIMED 08/18/1999
TITLE OF INVENTION AXIAL PISTON DRIVE WITH A CONTINUOUSLY ADJUSTABLE PISTON STROKE		
APPLICANT(S) FOR DO/EO/US THOMAS DIEDEMANN and OTFRIED SCHWARZKOPF		
<p>Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:</p> <ol style="list-style-type: none"> <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 371. <input type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371. <input type="checkbox"/> This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below. <input type="checkbox"/> The US has been elected by the expiration of 19 months from the priority date (Article 31). <input type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2)) <ol style="list-style-type: none"> <input type="checkbox"/> is attached hereto (required only if not communicated by the International Bureau). <input type="checkbox"/> has been communicated by the International Bureau. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US). <input checked="" type="checkbox"/> A English language translation of the International Application as filed (35 U.S.C. 371(c)(2)). <ol style="list-style-type: none"> <input checked="" type="checkbox"/> is attached hereto. <input type="checkbox"/> has been previously submitted under 35 U.S.C. 154(d)(4). <input type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)) <ol style="list-style-type: none"> <input type="checkbox"/> are attached hereto (required only if not communicated by the International Bureau). <input type="checkbox"/> have been communicated by the International Bureau. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired. <input type="checkbox"/> have not been made and will not be made. <input type="checkbox"/> A English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)). <input type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). <input type="checkbox"/> A English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)). <p>Items 11 to 20 below concern other document(s) or information included:</p> <ol style="list-style-type: none"> <input type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98. <input type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included. <input checked="" type="checkbox"/> A FIRST preliminary amendment. <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment. <input type="checkbox"/> A substitute specification. <input type="checkbox"/> A change of power of attorney and/or address letter. <input type="checkbox"/> A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821-1.825. <input type="checkbox"/> A second copy of the published international application under 35 U.S.C. 154(d)(4). <input type="checkbox"/> A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4). <input checked="" type="checkbox"/> Other items or information: <ul style="list-style-type: none"> <input type="checkbox"/> Applicant claims small entity status. <input checked="" type="checkbox"/> Supplement to Transmittal Letter. 		

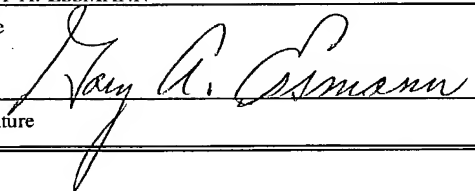
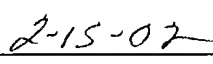
U.S. APPLICATION NO. (if known, see 37 CFR 1.5) <div style="font-size: 1.5em; font-weight: bold;">10/049690</div>		INTERNATIONAL APPLICATION NO. PCT/EP00/08084		ATTORNEY'S DOCKET NUMBER 825-161	
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21. <input type="checkbox"/> The following fees are submitted: <div style="margin-left: 20px;"> Basic National Fee (37 CFR 1.492(a)(1)-(5)): Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO..... \$ 1,040.00 International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO..... \$ 890.00 International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO \$ 740.00 International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4).. \$ 710.00 International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims satisfied provisions of PCT Article 33(1)-(4)..... \$ 100.00 ENTER APPROPRIATE BASIC FEE AMOUNT = </div>				CALCULATIONS PTO USE ONLY <div style="border: 1px solid black; height: 100px; width: 100%;"></div>	
Surcharge of \$130.00 for furnishing the oath or declaration later than months from the earliest claimed priority date (37 C.F.R. 1.491(3)). <input type="checkbox"/> 20 <input checked="" type="checkbox"/> 30				+ 130.00	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total Claims	10 - 20 =		x \$ 18.00		
Independent Claims	1 - 3 =		x \$ 84.00		
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ \$280.00		
TOTAL OF ABOVE CALCULATIONS =				\$1020.00	
<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.					
SUBTOTAL =				\$1020.00	
Processing fee of \$130.00 for furnishing the English Translation later than months from the earliest claimed priority date (37 C.F.R. 1.492(f)). <input type="checkbox"/> 20 <input type="checkbox"/> 30				+	
TOTAL NATIONAL FEE =				\$1020.00	
Fee for recording the enclosed assignment (37 C.F.R. 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). \$40.00 per property				+	
TOTAL FEES ENCLOSED =				\$1020.00	
				Amount to be refunded:	
				Charged:	

a. <input checked="" type="checkbox"/> A check in the amount of \$ 1020.00 to cover the above fees is enclosed. b. <input type="checkbox"/> Please charge my Deposit Account No. _____ in the amount of \$ _____ to cover the above fees. A duplicate copy of this sheet is enclosed. c. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 01.2000. A duplicate copy of this sheet is enclosed. d. <input type="checkbox"/> Fees are to be charged to a credit card. WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.	NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status. SEND ALL CORRESPONDENCE TO: ANDRUS, SCEALES, STARKE & SAWALL, LLP 100 East Wisconsin Avenue, Suite 1100 Milwaukee, Wisconsin 53202 Phone: (414) 271-7590 Fax: (414) 271-5770
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Signature _____ Date 2-15-02

 Name GARY A. ESSMANN Reg. No. 29,376

U.S. APPLICATION NO. (if known, see 37 CFR 1.5) 10/049690	INTERNATIONAL APPLICATION NO. PCT/EP00/08084	ATTORNEY'S DOCKET NUMBER 825-161
CERTIFICATE OF EXPRESS MAIL		
I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as EXPRESS MAIL-POST OFFICE TO ADDRESSEE, in an envelope addressed to: BOX PCT, COMMISSIONER OF PATENTS AND TRADEMARKS, WASHINGTON, D.C. 20231 on the <u>15th</u> day of February, 2002. Express Mail Label <u>EL 812734005 US</u> .		
GARY A. ESSMANN	29,376	
Name	Reg. No.	
		
Signature	Date	

JC11 Rec'd PGT/PTO 15 FEB 2002

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of:) AXIAL PISTON DRIVE WITH A
) CONTINUOUSLY ADJUSTABLE
 THOMAS TIEDEMANN and) PISTON STROKE
 OTFRIED SCHWARZKOPF)

PRELIMINARY AMENDMENT

Milwaukee, Wisconsin 53202

Box Patent Application
 Asst. Commissioner for Patents
 Washington, D.C. 20231

Sir:

Prior to computing the filing fee in this application, kindly amend the above identified application, as follows. The filing fee is to be computed on the amended claims.

In the Specification:

Beginning at page 1, between the title and the first line of text, the specification has been amended as follows:

CROSS REFERENCE TO RELATED APPLICATION

The present application is the U.S. national stage application of International Application PCT/EP00/08084, filed August 18, 2000, which international application was published on February 22, 2001 as International Publication WO 01/12989 A1 in the German language. The International Application claims priority of German Patent Application 199 39 131.9, filed August 18, 1999.

In the Claims:

Claim 1 has been amended as follows:

1. Axial piston drive with a continuously adjustable piston stroke, comprising a drive shaft (10, 12) on which a swash plate (16) is supported in a crank chamber (14) in such a way as to be tiltable and displaceable in the axial direction, and with a controller (18, 20) by means of which an tilt angle and an axial position of the

THOMAS TIEDEMANN and
OTFRIED SCHWARZKOPF

Atty. Docket No. 825-161

swash plate (16) can be adjusted, and with at least one piston (26, 28) connected to the swash plate (16) so that it can be actuated to move within a cylinder (22, 24), wherein the controller (18, 20) incorporates an adjustment unit (30, 32) that is separated from the piston (26, 28) and hydraulically driven,

characterized in that the adjustment unit (30, 32) is supplied with compressed oil by a hydraulic unit that is independent of the medium being propelled by the piston (26, 28).

Cancel claim 2

Cancel claim 3

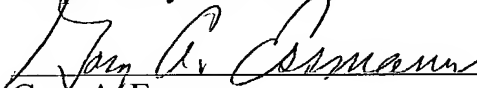
Add new claim 11 as follows:

11. Axial piston drive according to claim 1, characterized in that the adjustment unit (30, 32) is driven hydraulically.

Add new claim 12 as follows:

12. Axial piston drive according to claim 1, characterized in that the swash plate (16) is support on a joint head (48, 50) that can be axially displaced by means of a setting piston (44, 46) of the adjustment unit (30, 32) and the swash plate (16) is connected by an off-centre joint (52) to a component (54) that is fixed in the axial direction.

Respectfully submitted,



Gary A. Essmann
(Reg. No. 29,376)

ANDRUS, SCEALES, STARKE & SAWALL, LLP
100 East Wisconsin Avenue, Suite 1100
Milwaukee, Wisconsin 53202
(414) 271-7590
Atty. Docket No. 825-161

THOMAS TIEDEMANN and
OTFRIED SCHWARZKOPF

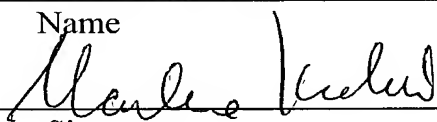
Atty. Docket No. 825-161

CERTIFICATE OF EXPRESS MAIL

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Marlene Kubiak

Name



Signature

Reg. No.

February 15, 2002

Date

VERSION WITH MARKINGS TO SHOW CHANGES MADE

Attorney Docket No. 825-161

In the specification:

Please add the following paragraph at page 1, between the title and the first line of text as follows:

CROSS REFERENCE TO RELATED APPLICATION

The present application is the U.S. national stage application of International Application PCT/EP00/08084, filed August 18, 2000, which international application was published on February 22, 2001 as International Publication WO 01/12989 A1 in the German language. The International Application claims priority of German Patent Application 199 39 131.9, filed August 18, 1999.

In the claims:

Claim 1 has been amended as follows:

1. Axial piston drive with a continuously adjustable piston stroke, comprising a drive shaft (10, 12) on which a swash plate (16) is supported in a crank chamber (14) in such a way as to be tiltable and displaceable in the axial direction, and with a controller (18, 20) by means of which an tilt angle and an axial position of the swash plate (16) can be adjusted, and with at least one piston (26, 28) connected to the swash plate (16) so that it can be actuated to move within a cylinder (22, 24), ~~characterized in that~~ wherein the controller (18, 20) incorporates an adjustment unit (30, 32) that is separated from the piston (26, 28) and hydraulically driven,

characterized in that the adjustment unit (30, 32) is supplied with compressed oil by a hydraulic unit that is independent of the medium being propelled by the piston (26, 28).

Delete claim 2

Delete claim 3

Attorney Docket No. 825-161

Add new claim 11

11. Axial piston drive according to claim 1, characterized in that the adjustment unit (30, 32) is driven hydraulically.

Add new claim 12

12. Axial piston drive according to claim 1, characterized in that the swash plate (16) is support on a joint head (48, 50) that can be axially displaced by means of a setting piston (44, 46) of the adjustment unit (30, 32) and the swash plate (16) is connected by an off-centre joint (52) to a component (54) that is fixed in the axial direction.

(12) NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES
PATENTWESENS (PCT) VERÖFFENTLICHTE INTERNATIONALE ANMELDUNG

(19) Weltorganisation für geistiges Eigentum
Internationales Büro



(43) Internationales Veröffentlichungsdatum
22. Februar 2001 (22.02.2001)

PCT

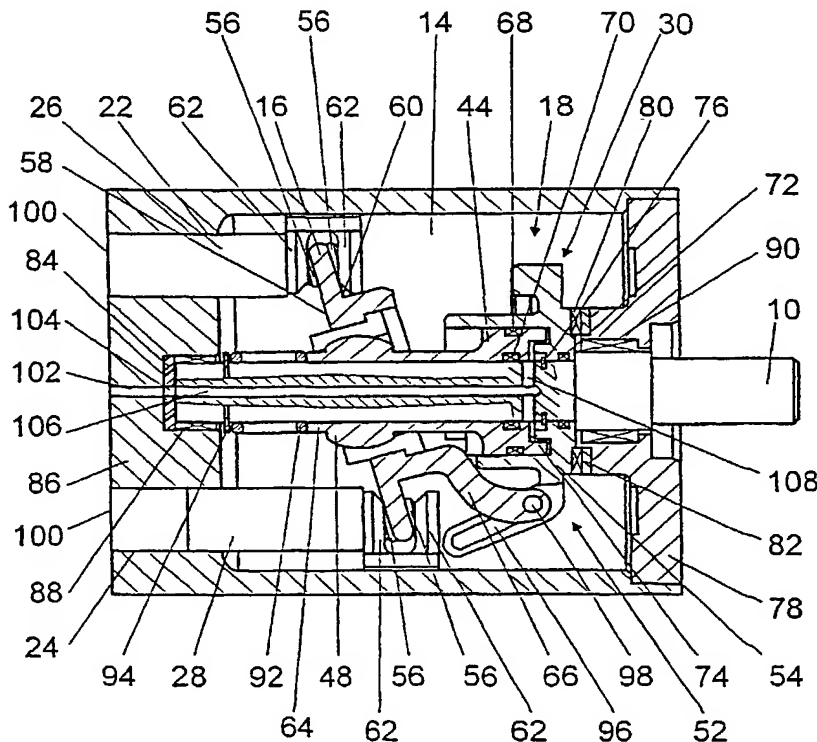
(10) Internationale Veröffentlichungsnummer
WO 01/12989 A1

- (51) Internationale Patentklassifikation⁷: F04B 27/18. (71) Anmelder (für alle Bestimmungsstaaten mit Ausnahme von US): ZEXEL GMBH [DE/DE]; Zeppelinstrasse 5, 64331 Weiterstadt (DE).
- (21) Internationales Aktenzeichen: PCT/EP00/08084 (72) Erfinder; und
- (22) Internationales Anmeldedatum: 18. August 2000 (18.08.2000) (75) Erfinder/Anmelder (nur für US): TIEDEMANN THOMAS [DE/DE]; Friedrich-Engels-Strasse 28, 71636 Ludwigsburg (DE). SCHWARZKOPF, Otfried [DE/DE]; Maichinger Strasse 10, 71106 Magstadt (DE).
- (25) Einreichungssprache: Deutsch (74) Anwälte: POPP, Eugen usw.; Meissner, Bolte & Partner. Postfach 86 06 24, 81633 München (DE).
- (26) Veröffentlichungssprache: Deutsch
- (30) Angaben zur Priorität: 199 39 131.9 18. August 1999 (18.08.1999) DE (81) Bestimmungsstaaten (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU,

[Fortsetzung auf der nächsten Seite]

(54) Title: AXIAL-PISTON DRIVE SYSTEM WITH A CONTINUOUSLY ADJUSTABLE PISTON STROKE

(54) Bezeichnung: AXIALKOLBENTRIEBWERK MIT EINEM STUFENLOS VERSTELLBAREN KOLBENHUB



(57) Abstract: The invention relates to an axial-piston drive system with a continuously adjustable piston stroke. The inventive drive system has a drive shaft (10, 12) on which a swash plate (16) is mounted in a crank chamber (14) in such a way that it is tiltable and axially displaceable. The drive system also comprises a control device (18, 20) by which means a tilting angle and an axial position of the swash plate (16) can be adjusted, and at least one piston (26, 28) which is connected to the swash plate (16) in a driving manner and can move in a cylinder (22, 24). According to the invention, said control device (18, 20) has an adjusting unit (30, 32) which is separate from the piston (26, 28).

(57) Zusammenfassung: Die Erfindung geht aus von einem Axialkolbentriebwerk mit einem stufenlos verstellbaren Kolbenhub, das eine Antriebswelle (10, 12) aufweist, auf der in einem Kurbelraum (14) eine Schrägscheibe (16) verkipptbar und in axialer Richtung verschiebbar gelagert ist und

[Fortsetzung auf der nächsten Seite]

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5

Axial piston drive with a continuously adjustable piston stroke

10 State of the art

The invention relates to an axial piston drive with a continuously adjustable piston stroke according to the precharacterizing clause of Claim 1.

15 The use of axial piston drive with a continuously adjustable piston stroke is known in particular for motor-vehicle air conditioners, where they serve as coolant condensers.

The main components of an air conditioner for a motor vehicle are a coolant condenser, a first heat exchanger, the so-called
20 evaporator, a second heat exchanger, an expansion organ and conduits that connect the components to one another. The role of the coolant condenser is to suck a coolant out of the evaporator, in which the coolant evaporates under heat absorption, and to condense it at a higher pressure level.
25 Subsequently, in the second heat exchanger, the coolant can release the heat at a higher temperature level, and in the expansion organ it is returned to a pressure level corresponding to that of the evaporator.

The output of the coolant condenser can be continuously
30 adjusted by way of the speed of a drive motor and in an especially energetically favourable manner, in the case of axial piston drives, by way of the piston stroke. Known axial piston drives or axial piston condensers for vehicle air conditioners comprise a drive shaft operated by way of a

pulley. Within a crank chamber a swash plate is supported on the drive shaft so that it is unrotatably fixed and can be tilted by way of a joint. The swash plate drives at least one piston that can move within a cylinder. In order to absorb

5 tractive and pressure loads, each such piston is connected to the swash plate by way of two hinge yokes, one at the bearing surface of the swash plate that faces the piston and the other at the surface that faces away. With their flat surfaces

10 contacting the bearing surfaces of the swash plate, the hinge yokes run at full circumferential velocity with a superimposed radial movement, which results in an elliptical path. The hinge yokes are seated with their rounded surfaces in sphere shaped formed bearings of the pistons, within which there is comparatively little relative movement during operation.

15 Furthermore, the connection between the the swash plate and the piston can be formed by way of a wobble plate rather than hinge yokes as described above. The wobble plate is secured against rotation with respect to the drive shaft by either a housing or piston rods. A bearing between the swash plate and the wobble

20 plate absorbs the entire relative movement. The wobble plate performs only a wobbling movement as a result of the rotation of the swash plate.

The piston stroke and hence the output of the axial piston drive unit is adjusted by altering the tilt angle of the swash

25 plate. A large tilt angle results in a long piston stroke and high output, whereas with a small tilt angle the piston stroke is shorter and the output lower. As a rule, the tilt angle of the swash plate is limited to a minimal and a maximal value by two stops. Ordinarily one or two guide pins are needed to guide

30 the tilting movement in a specified manner and to avoid jamming. The tilt limiters, i.e. the stops, can be integrated into the guide pins.

25 In one embodiment it is proposed to connect the hydraulic
adjustment unit to the crank chamber by way of a drain, which
is a particularly useful arrangement in that the oil trap and
the adjustment unit can be used to transport the lubricant back
into the crank chamber. In this process, a influx from the oil
30 trap to the adjustment unit and/or the drain from the
adjustment unit to the crank chamber can be made controllable.
If only the drain or the influx is designed to be controllable,

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whichever of these is not controlled can incorporate an inexpensive throttling site.

In the case in which only the drain or the influx can be controlled, it may happen that more lubricant is separated out
 5 in the oil separator than is needed for the adjustment unit or for the control. To ensure that the amount of lubricant in the crank chamber is always appropriate, in one embodiment it is proposed that there be disposed in the oil separator and/or in the crank chamber at least part of an oil-level controller
 10 which, when an oil level in the oil separator is exceeded and/or the oil in the crank chamber falls below a certain level, connects the oil separator to the crank chamber by way of a channel. It is further possible for the oil separator to be permanently connected to the crank chamber by a channel and
 15 a throttling site, or the oil separator and the amount of oil coordinate with respect to one another in such a way that the oil separator overflows before an oil or lubricant deficiency develops in the crank chamber. The overflowing oil can subsequently be sent into the crank chamber, for example
 20 together with a coolant for an air conditioner. With a controlled influx and a controlled drain, it can be ensured that the crank chamber always contains an adequate amount of lubricant.

The swash plate can be constructed so as to be tiltable and
 25 axially displaceable in various ways, as seems appropriate to a person skilled in the art. For example, the swash plate can be supported on a Z shaft with a tilted bore of bearing, and a stroke movement can be superimposed by a rotational movement of the bearing disk, and so on. In one embodiment of the invention
 30 it is proposed that the swash plate be supported on a joint head that can be axially displaced by means of a setting piston incorporated in the adjustment unit, and that the swash plate also be connected by way of an off-centre joint to a component

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that is fixed in the axial direction. A structurally simpler and more economical displacement mechanism can thus be achieved, in which the tilt angle and axial position of the swash plate are related to one another in a specified manner.

5 The top-dead-centre point of the piston within the cylinder can be maintained and it becomes possible to avoid a damage space and energy losses, as a result of which the axial piston drive can be used particularly advantageously as a condenser in an air conditioner. The condenser can be designed as a pure swash-
10 plate condenser or as a wobble-plate condenser. Furthermore, the solution in accordance with the invention can be employed with gear mechanisms and the like.

It is advantageous to construct the setting piston and the joint head in one piece, which can provide a saving in extra
15 components as well as the effort of assembly and expense. The adjustment unit can be so disposed that it either rotates with the drive shaft, partially or completely, or is unrotatably fixed within a housing. Furthermore, the adjustment unit can act on the swash plate either from the side away from the
20 piston or from the side facing the piston.

Drawing

Additional advantages will be apparent from the following description of drawings that show exemplary embodiments of the invention. The drawings, the description and the claims contain
25 numerous characteristics in combination. A person skilled in the art will be able also to consider the characteristics individually and to assemble them into other useful combinations.

The individual figures show the following:

Fig. 1 an axial piston drive with the piston at the
maximal end of its stroke, in section,

Fig. 2 an axial piston drive with the piston at the
minimal end of its stroke, in section,

5 Fig. 3 part of a variant according to Fig. 1, and

Fig. 4 a schematic diagram of a form of hydraulic
control.

Description of the exemplary embodiments

Fig. 1 shows an axial piston drive for an air conditioner of a
10 motor vehicle, which operates as a condenser. The axial piston
drive comprises a drive shaft 10 on which a swash plate 16 is
supported within a crank chamber 14. The driving action of the
swash plate 16 is exerted by way of hemispherical hinge yokes
56, which connect it to pistons 26, 28 that are guided within
15 cylinders 22, 24. To absorb tractive and pressure loads, each
piston 26, 28 is connected to the swash plate 16 by way of two
hinge yokes 56, one of which contacts the bearing face 58 that
faces away from the pistons 26, 28 while the other contacts the
bearing Face 60 that faces towards the pistons 26, 28. The
20 hinge yokes 56 run, by way of their flat surfaces, along the
bearing faces 58, 60 of the swash plate 16 at the full
circumferential velocity with superimposed radial movement, as
a result of which an elliptical track is produced. The rounded
surfaces of the hinge yokes 56 are seated in sphere shaped
25 formed bearings 62 of the pistons 26, 28, within which there is
comparatively little relative movement during operation.

The swash plate is connected to the drive shaft 10 in a
unrotatably fixed manner, by way of a joint head 48 of a sleeve
64. So that the piston stroke and hence the output of the axial

piston drive can be continuously adjusted, the swash plate 16 is made so that it can be tilted on the joint head 48 by means of a controller 18 and moved in the axial direction along with the sleeve 64. When the tilt angle is large, a long piston stroke and a high output are achieved, while with a small tilt angle the piston stroke is short and the output low (Figs. 1 and 2).

In accordance with the invention the controller 18 comprises a hydraulic adjustment unit 30 that is separate from the pistons 26, 28. The adjustment unit 30 incorporates a setting piston 44 formed in one piece with the sleeve 64 and the joint head 48. The setting piston 44 is guided within a cylinder formed by an adjustor housing 54. The adjustor housing 54 is attached to the drive shaft 10 in a form-fitting manner, in the radial direction by way of a fitting means not shown here, and axially by way of a tension ring 76. The drive shaft 10 is axially supported in the direction away from the cylinders 22, 24 by the adjustor housing 54, an axial bearing 80 and a running plate 82 set into a cover 78; in the direction towards the cylinders 22, 24 it rests against a housing 86 of the axial piston drive by way of an axial slide bearing 84. The drive shaft 10 is additionally supported in the cover 78 and in the housing 86 by way of two radial bearings 88, 90.

The positioning piston 44, together with the cylinder, encloses a pressure space 74 that is sealed off by three seals 68, 70, 72. The swash plate 16 is connected to the adjustor housing 54 by way of a joining element 66, which is formed integrally with the swash plate 16, and by an off-centre joint 52.

When compressed oil enters the pressure space 74, the positioning piston 44 is displaced, together with the sleeve 64, the joint head 48 and the swash plate 16, in the direction towards the cylinders 22, 24, against a prestressed pressure

spring 92 (Fig. 2). The pressure spring 92 is nonrotatably attached to the drive shaft 10 and is braced against a tension ring 94 in the direction away from the setting piston 44. By the off-centre joint 52, formed by a bolt 98 that is fixed to the joining element 66 and is guided within a slot 96, the stroke movement of the swash plate 16 causes a moment of tilt acting on the swash plate 16. Upon the stroke movement of the swash plate 16 is superimposed a tilting movement, guided by the bolt 98 in the slot 96, so that in all cases a top-dead-centre point 100 of the piston 26, 28 within the cylinders 22, 24 is preserved. So that only a small amount of oil is required, the volume of the pressure space 74 is preferably small.

The adjustment unit 30, specifically the setting piston 44, is supplied with compressed oil from an oil separator disposed downstream of the cylinders 22, 24, by way of an axial bore 102, 104, 106 in the housing 86, in the slide bearing 84 and in the drive shaft 10, and by way of a radial bore 108 in the drive shaft 10 (Figs. 1, 2 and 4). The compressed oil is advantageously fed into the drive shaft 10 axially, in the middle. In this region the relative movement between the drive shaft 10 and the slide bearing 84 is advantageously made small. Furthermore, the slide bearing 84 can additionally be used as a seal. If no oil pressure has yet developed in the oil separator 34 when the mechanism is first started, the pressure spring 92 sets the tilt angle to maximal, which ensures a build-up of pressure.

The adjustment unit 30 is connected to the oil separator 34 by a influx 38 and to the crank chamber 14 by a drain 36. The influx 38 and drain 36 can each be controlled by a valve 110, 112. If a higher controlling torque is needed, the valve 110 opens. The oil flows at a higher pressure level into the adjustment unit 30 and acts on the setting piston 44. The valve

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axial bearing 128 that acts on both sides, such that the positioning piston 46 forms inner bearing faces whereas the sleeve 120 and a fastening element 130 form outer bearing faces. With the fastening element 130, which is connected to the sleeve 120 by a screw thread 132, the degree of axial play in the axial bearing 128 can be set to a specified value. The adjustment unit 32, i.e. the setting piston 46, is supplied with compressed oil from an oil separator 34 by way of an axial bore 134, as is the adjustment unit 30 (cf. relevant part of Fig. 4).

List of reference numerals

10	Drive shaft	74	Pressure space
12	Drive shaft	76	Tension ring
14	Crank space	78	Cover
5 16	Swash plate	80	Axial bearing
18	Controller	82	Thrust washers
20	Controller	84	Slide bearing
22	Cylinder	86	Housing
24	Cylinder	88	Bearing
10 26	Piston	90	Bearing
28	Piston	92	Pressure spring
30	Adjustment unit	94	Tension ring
32	Adjustment unit	96	Slot
34	Oil spearator	98	Bolt
15 36	Drain	100	Top-dead-centre
38	Influx	102	Bore
40	Oil-level controller	104	Bore
42	Channel	106	Bore
44	Setting piston	108	Bore
20 46	Setting piston	110	Valve
48	Joint head	112	Valve
50	Joint head	114	Housing
52	Joint	116	Seal
54	Component	118	Seal
25 56	Hinge yoke	120	Joint sleeve
58	Bearing face	122	Recess
60	Bearing face	124	Pressure spring
62	Bearing	126	Shoulder
64	Joint sleeve	128	Bearing
30 66	Joining element	130	Fastening element
68	Seal	132	Screw thread
70	Seal	134	Bore
72	Seal	136	Pressure spring

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15 Claims

1. Axial piston drive with a continuously adjustable piston stroke, comprising a drive shaft (10, 12) on which a swash plate (16) is supported in a crank chamber (14) in such a way as to be tiltable and displaceable in the axial direction, and with a controller (18, 20) by means of which an tilt angle and an axial position of the swash plate (16) can be adjusted, and with at least one piston (26, 28) connected to the swash plate (16) so that it can be actuated to move within a cylinder (22, 24), characterized in that the controller (18, 20) incorporates an adjustment unit (30, 32) separated from the piston (26, 28).

2. Axial piston drive according to Claim 1, characterized in that the adjustment unit (30, 32) is driven hydraulically.

3. Axial piston drive according to Claim 2, characterized in that the adjustment unit (30, 32) is supplied with compressed oil by a hydraulic unit that is independent of the medium being propelled by the piston (26, 28).

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4. Axial piston drive according to Claim 2, characterized in that the hydraulic adjustment unit (30, 32) is supplied with compressed oil by an oil separator (34) disposed downstream of the cylinder (22, 24).

5. Axial piston drive according to Claim 4, characterized in that the adjustment unit (30, 32) is connected to the crank chamber (14) by way of a drain (36), and a influx (38) from the oil separator (34) to the adjustment unit (30, 32) or the drain (36) from the adjustment unit (30, 32) to the crank chamber (14) can be controlled.

6. Axial piston drive according to Claim 5, characterized in that in the oil separator (34) and/or in the crank chamber (14) at least part of an oil-level controller (40) is disposed which, when a specified oil level in the oil separator (34) is exceeded and/or when the oil in the crank chamber (14) falls below a certain level, connects the oil separator (34) to the crank chamber (14) by way of a channel (42).

7. Axial piston drive according to Claim 5, characterized in that in the oil separator and an amount of oil that is present are matched to one another in such a way that before an oil deficiency appears in the crank chamber (14), the oil separator overflows and the overflowing oil flows back into the crank chamber (14).

8. Axial piston drive according to Claim 4, characterized in that in the adjustment unit (30, 32) is connected to the crank chamber (14) by way of a drain (36), and a influx (38) from the oil separator (34) to the adjustment unit (30, 32) and the drain (36) from the adjustment unit (30, 32) to the crank chamber (14) can be controlled.

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9. Axial piston drive according to one of the preceding
claims, characterized in that the swash plate (16) is supported
on a joint head (48, 50) that can be axially displaced by means
of a setting piston (44, 46) of the adjustment unit (30, 32)
5 and the swash plate (16) is connected by an off-centre joint
(52) to a component (54) that is fixed in the axial direction.

10. Axial piston drive according to Claim 9, characterized in
that in the setting piston (44) and the joint head (48) are
constructed in one piece.

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Axial piston drive with a continuously adjustable piston stroke

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Abstract

The invention relates to an axial piston drive with a
 10 continuously adjustable piston stroke, which comprises a drive
 shaft (10, 12) on which a swash plate (16) is supported in a
 crank chamber (14) in such a way as to be tiltable and
 displaceable in the axial direction, as well as a controller
 (18, 20) by means of which an tilt angle and an axial position
 15 of the swash plate (16) can be adjusted, and at least one
 piston (26, 28) connected to the swash plate (16) so that it
 can be actuated to move within a cylinder (22, 24).

It is proposed that the controller (18, 20) incorporates an
 20 adjustment unit (30, 32) separated from the piston (26, 28).

(Fig. 1)

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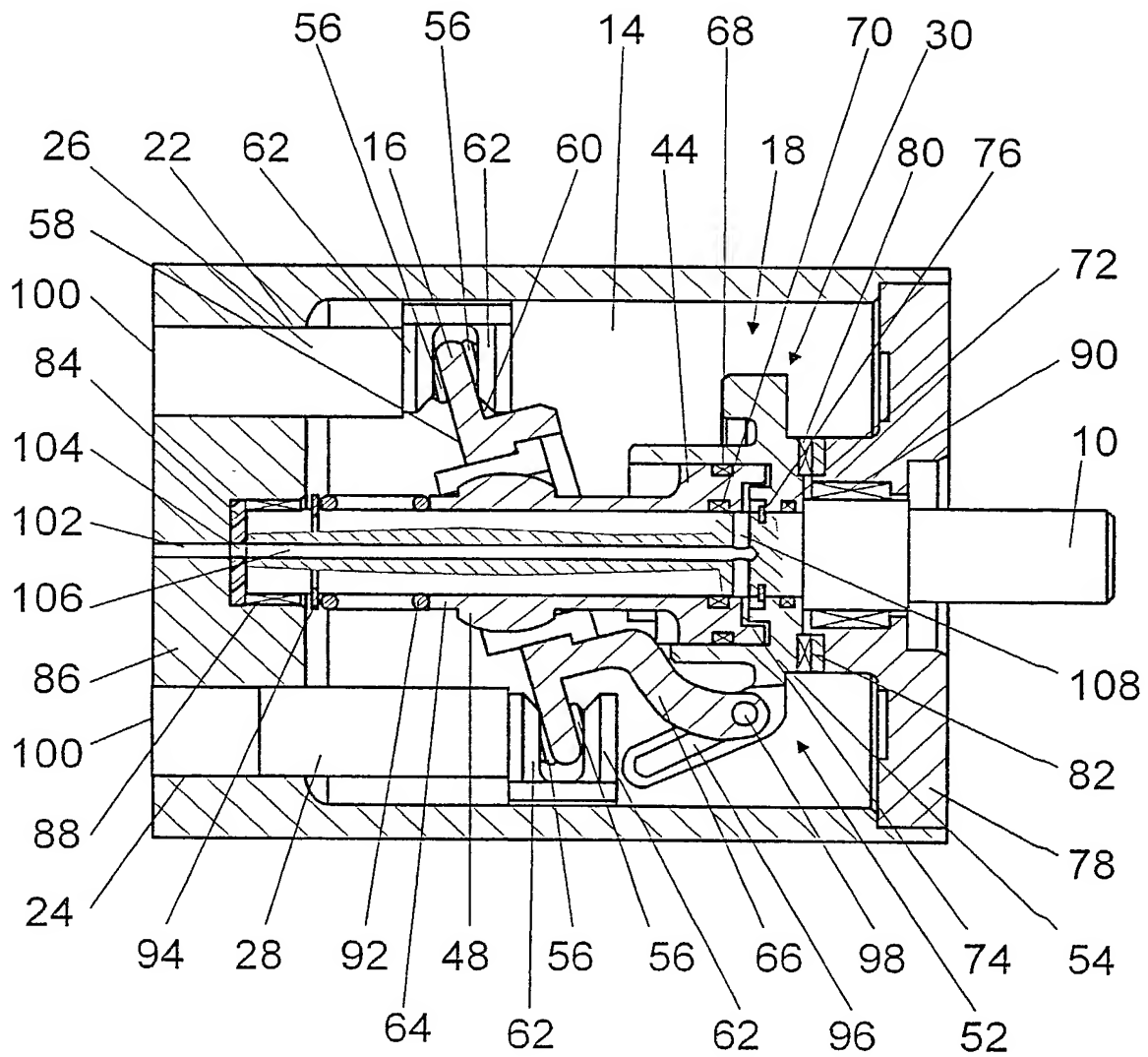


Fig. 1

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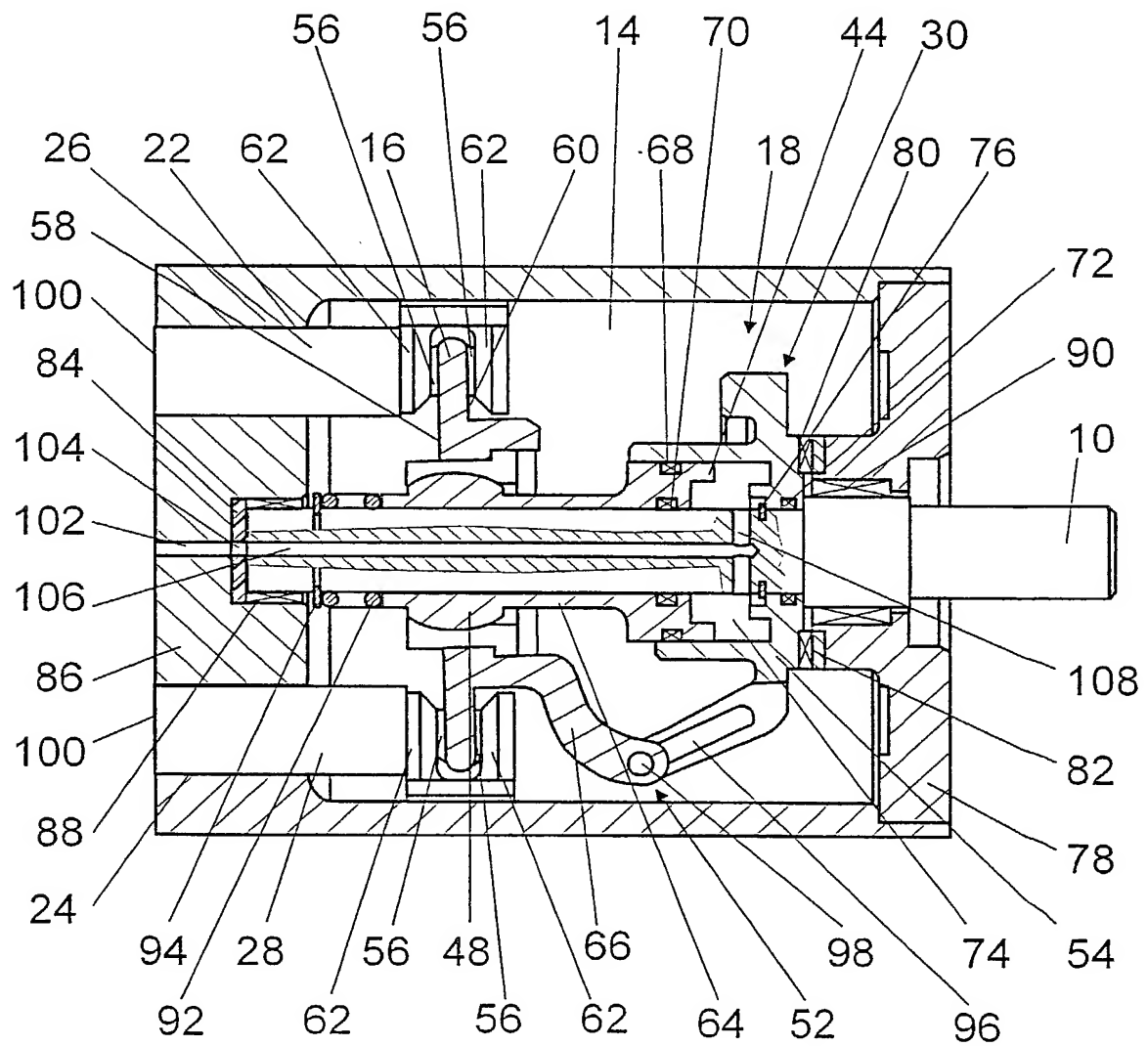


Fig. 2

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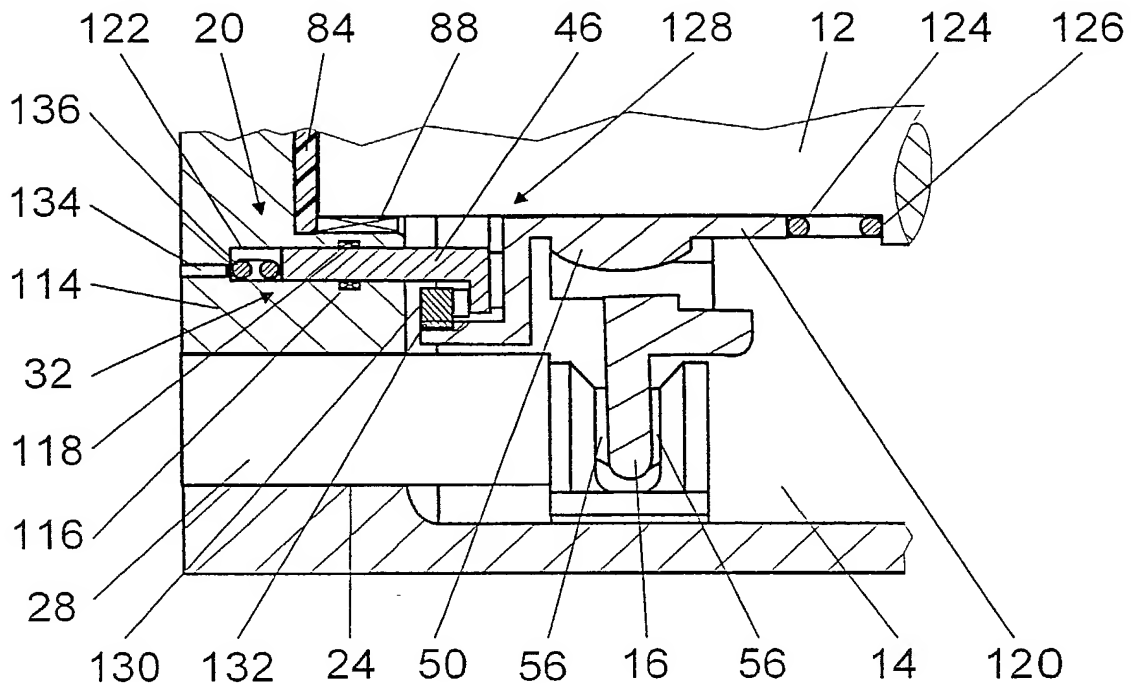


Fig. 3

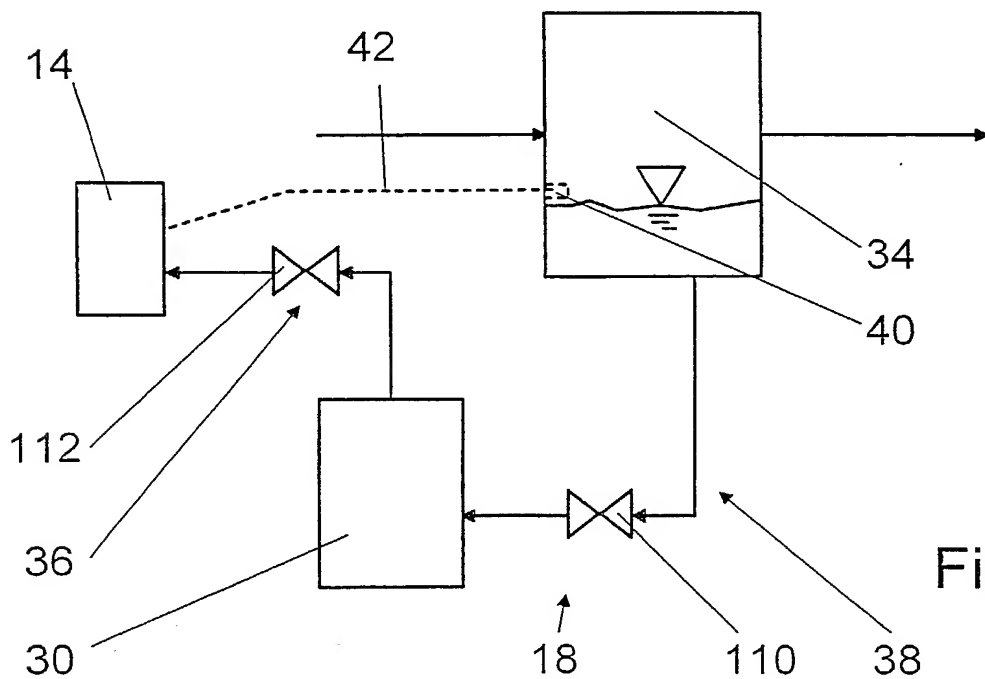


Fig. 4

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Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

PTO/SB/01 (8/96) Declaration OR Declaration <input type="checkbox"/> Submitted with Initial Filing <input checked="" type="checkbox"/> Submitted after Initial Filing	Attorney Docket Number: 825-161	
	First Named Inventor: Thomas Tippmann	
	COMPLETE IF KNOWN	
	Application Number	
	Filing Date	
		Group Art Unit
		Examiner Name

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

AXIAL PISTON DRIVE WITH A CONTINUOUSLY ADJUSTABLE PISTON STROKE

(Title of the invention)

the specification of which

☐ is attached hereto

OR

☒ was filed on (MM/DD/YYYY) as United States Application Number or PCTInternational Number
(if applicable).

PCT/EP00/08084

and was amended on (MM/DD/YYYY)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37 Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code §119(a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT International application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Copy Attached?	
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199 39 131.9	Germany	08/18/1999	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>

☐ Additional foreign application numbers are listed on a supplemental priority sheet attached hereto.

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I hereby claim the benefit under Title 35, United States Code §120 of any United States application(s), or §365 of any PCT international application designated the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States of PCT International application in the manner provided by the first paragraph of Title 35, United States Code §112. I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.							
U.S. Parent Application Number		PCT Parent Number		Parent Filing Date (MM/DD/YYYY)		Parent Patent Number (if applicable)	
<input type="checkbox"/> Additional U.S. or PCT international application numbers are listed on a supplemental priority sheet attached hereto.							
As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:							
Name		Registration Number		Name		Registration Number	
Daniel D. Fetterley		20,323		Joseph D. Kuborn		40,880	
George H. Solveson		25,927		Jeffrey S. Sokol		35,686	
Gary A. Essmann		29,376		William L. Falk		27,709	
Thomas M. Wozny		28,922					
Michael E. Taken		28,120					
Joseph J. Jochman, Jr.		25,058					
<input type="checkbox"/> Additional attorney(s) and/or agent(s) named on a supplemental sheet attached hereto.							
<input checked="" type="checkbox"/> Please direct all correspondence to: Name Gary A. Essmann							
Address Andrus, Scales, Starke & Sawall, LLP							
Address 100 East Wisconsin Avenue, Suite 1100							
City Milwaukee		State Wisconsin		Zip 53202-4178			
Country United States		Telephone (414) 271-7590		Fax (414) 271-3770			
I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.							
Name of Sole or First Inventor: <input type="checkbox"/> A petition has been filed for this unsigned inventor.							
Given Name (first and middle (if any))				Family Name or Surname			
THOMAS				TIEDEMANN			
Inventor's Signature		Thomas F. TieDEMANN		Date		May 31, 2002	
RESIDENCE: City		Ludwigsburg DEU State		Country		Germany	
Citizenship		German					
POST OFFICE ADDRESS				Friedrich-Engels-Strasse 28			
City		Ludwigsburg		State		Germany	
Zip		D-71636		Country		Germany	
Name of Second Inventor: <input type="checkbox"/> A petition has been filed for this unsigned inventor.							
Given Name (first and middle (if any))				Family Name or Surname			
OTFRIED				SCHWARZKOPF			
Inventor's Signature		Otfried Schwarzkopf		Date		June 19, 2002	
RESIDENCE: City		Magstadt DEU State		Country		Germany	
Citizenship		German					
POST OFFICE ADDRESS				Maichinger Strasse 10			
City		Magstadt		State		Germany	
Zip		D-71106		Country		Germany	